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Communicating science in the digital era: the example of the virtual tours and the Solar System Console of the "Time Machines" exhibition

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Abstract. The digital revolution is transforming the communication of scientific knowledge, introducing new interactive exploration methods in visitor centers and exhibitions. The "Time Machines" exhibition, created by the Italian National Institute of Astrophysics (INAF), in collaboration with Pleiadi, features interactive tools that engage the public in modern astrophysics. A notable example is a touch table, called the "Solar System Console", that allows users to explore the Solar System by accessing and manipulating informational cards, facilitating individual and collaborative learning in an engaging environment. Another highlight is the virtual tour of INAF's main observatories, providing a captivating 360° experience that immerses viewers in key locations of Italian astrophysical research. Overall, these emerging technologies and interactive exhibits offer effective ways to promote scientific culture nationally and internationally. In this paper, we will present the development of these projects together with the "lessons learned", challenges faced, and future evolution based on the "Time Machines" exhibition experience.

Key words. Science communication; astrophysics; exhibition; exhibit

1. Introduction

The digital revolution has transformed science communication, moving beyond static displays to dynamic, interactive explorations. Visitor centers and museums are now employing cutting-edge technologies, like virtual reality simulations that transport visitors to distant planets, to create truly immersive learning experiences (Marques et al. (2021)). This transformation empowers visitors to engage more deeply with scientific concepts and expand their understanding of the boundless possibilities of scientific discovery (Chastenay (2016)).

All these advancements have been thoughtfully incorporated into the design of the exhibition "Time Machines", ensuring that it not

only showcases the wonders of astrophysics but also fosters active participation and collaborative learning among visitors (Hayward & Hart (2015). By integrating interactive tools and immersive experiences, "Time Machines" aims to bridge the gap between complex scientific ideas and public understanding, making science both accessible and engaging for all.

'Time Machines' (Mignone et al. (2023)) is an exhibition of the Italian National Institute for Astrophysics (INAF) held in "Palazzo Esposizioni" in Via Nazionale Rome, Italy from the 25^{th} of November 2023 to the 24^{th} of March 2024. This was the first large exhibition conceived and realised by INAF, in collaboration with Pleiadi. It offered visitors an extraordinary journey through space and time, all the way to the far reaches of the known Universe, until the dawn of cosmic history, with the help of telescopes, the "time machines" of astronomers and astrophysicists. With a pop style and eighties flair, the exhibition exploited the light travel time – the farther astronomical objects we observe, the further we see back in time – to explore planets, stars and galaxies along an itinerary that is both physical and conceptual.

'Time Machines' integrated various interactive tools to tell the story of modern astrophysics, offering the public unique opportunities for active involvement and discovery. One example is the virtual tour of the INAF's main observatories. Wearing the virtual reality visor, the viewer is immersed in a high-impact 360° experience, exploring, while having fun, the key locations of Italian astrophysical research and the main celestial sources studied and observed in these places.

Another example is a touch table conceived and designed to offer adults and children the individual and/or collaborative opportunity to touch the Solar System by accessing, visualising and manipulating a series of information boards. Through this exhibit, users could select their favourite planet, explore its characteristics and immerse themselves in a wide range of virtual and multimedia content related to the Solar System. It is also a very useful tool from a didactic point of view, as it goes beyond traditional pen-and-paper teaching methods and facilitates more effective learning for the individual and the class group, creating a playful and stimulating environment (Gaylord-Opalewski (2019)).

In this paper, we will explore these two exhibits, detailing the development process from conception to realization. Additionally, we will examine their impact on the public and discuss future perspectives to enhance their effectiveness in upcoming exhibitions.

2. INAF Virtual Tour

Following the concept of the "Time Machines" exhibition targeted at a young audience and general public, it was necessary to offer a virtual reality experience. This kind of exhibit gives the opportunity to immerse visitors in the daily reality of the observatories, allowing them to physically interact with the INAF telescopes, which are the true protagonists of the exhibition, and to learn about the main scientific discoveries made possible through the use of these telescopes.

The design and development of this exhibit were led by the following objectives: allow visitors to visit the INAF telescopes (some of them not open to the public and difficult to reach), provide an engaging and immersive experience, and disseminate the scientific research conducted using these instruments. Finally, to achieve these objectives, it was necessary to take into account some constraints, mainly technical, defined by the location and the general design of the "Time Machines" exhibition. First of all, it was important to create a simple and intuitive interface that enables autonomous navigation for the users. The experience should not require a dedicated staff to guide the visitors in the virtual tour and did not depend on Wi-Fi usage, since the connection was not reliable. Furthermore, it was mandatory to develop a low-cost product due to budget constraints and ensure a quick tour experience of about 10/15 minutes as a maximum.

Taking into account those constraints and limitations, the tour was developed using the paid licensed software 3DVista. It allows a simple and intuitive production of a tour that can be loaded into the Meta Quest 2 viewer's

Fig. 1. Exhibit design. Pictures of the two stations of the Virtual Tour exhibit at the "Time Machines" exhibition (Credits: INAF/Paolo Soletta)

Fig. 2. Panorama. Example of two panorama regarding the Sardinia Radio Telescope included in the Virtual Tour

local memory and enjoyed without the use of an internet connection. In order to simplify the experience of the virtual tour and avoid any interaction with the controllers, a tailored tour that does not require the navigation with joysticks was created. The virtual tour was therefore designed and developed so that visitors could navigate it independently and intuitively using a pointer. This pointer, when positioned over the hotspots for a few seconds, allows the user to move from one panorama to another and/or start descriptive videos.

The exhibition design included two stations for virtual reality exhibits, as shown in the Figure 1. Each table had four seats, each corresponding to a virtual reality headset. The viewers were secured with cables fixed to the centre of the table. This configuration allowed visitors to sit down and look around 360 degrees from their seated position.

Thereafter, the selection of the INAF telescopes to be included in the tour was made. We selected the telescopes with ready-to-use 360-degree images and we chose one image of the exterior and one of the interior for each telescope. In particular, the ones included in the tour are: Galileo National Telescope at the La Palma Island, Sardinia Radio Telescope in Sardinia, Copernicus Telescope in Asiago, Radioastronomical Station in Medicina and Cassini Telescope in Loiano. In Figure 2, two examples are presented.

Furthermore, for each observatory, to describe the most relevant and recent research projects, 3 or 4 images have been chosen showing the most significant scientific discoveries made thanks to the use of these telescopes. For

each image, a video of about 1 minute has been created in which the importance of that particular scientific discovery is explained in a simple and accessible way.

The entire virtual tour has been developed in Italian, with translations in English for all the contents (audio and video), identified by different hotspots.

3. Solar System Console

The Console has been designed taking into account the following objectives: disseminate relevant knowledge about the Solar System; present the engagement of INAF in the exploration of the Solar System, experience a hands-on activity and facilitate learning in a fun way by playing with the touch table. Also for this exhibit, there were some constrains we have to take into account. In particular, we had to develop a simple and intuitive interface to allow an autonomous navigation of the public, without the help of a guide. Another goal was also to create an exhibit of high impact that captivates the audience and communicates a variety of contents.

To do so, the Solar System Console has been design and developed as a console that consists in a touch table and a big screen on the wall. Users interact with the exhibit trough the touch table and the screen shows the mirror of that table (see left image of Figure 3). This configuration gives the possibility to a large audience to see what the touch table is displaying and it has been developed with the aim of engaging a large number of people, such as classes of students.

The exhibit has been developed using a Wordpress website which was installed into the local memory of the computer under the touch table, without using the internet connection. For each object of the Solar System, namely planets, moons, comets, asteroids and dwarf planets, a fact sheet was created. In these webpages, all the information about the objects is presented together with a 3D model, that can be rotated and moved by the public. In the right image of Figure 3, the main menu of the interface was presented.

4. Future perspectives

While improvements have been made, there's still significant potential to create a truly seamless and elevated experience for the audience, free from any issues. To do so, we collected feedback from the audience and from the staff of Palazzo Esposizioni to understand the critical issues that arose in the exhibition.

The INAF telescope virtual tour requires a seamless VR experience, free from technical glitches. To achieve this, the Meta Quest 2 headset's reliance on pre-set virtual boundaries must be carefully considered during setup. This setting prevents users to hit objects in the room while using the headset with any app. However, if the border is crossed the application in use is automatically stopped for security reasons. This technical issue needs to be addressed for this exhibit by exploring alternative headset model and/or developing a different station where the devices are located. A possible solution could be an exhibit with a secured and specially designed helmet that houses the headset. This would eliminate the risk of users bumping into objects and ensure a safe and immersive 360° experience. Moreover, the exhibition's lack of dedicated staff presented a major challenge, as devices needed to be powered on and off daily to conserve battery life, further complicated by occasional device freezes. Utilizing dedicated apps for Meta Quest headsets, designed specifically for exhibitions, has the potential to address these challenges. This approach could provide a fully autonomous experience, eliminating the need for staff to guide the virtual tour, freeing up resources and improving user experience.

A straightforward improvement of the Solar System Console would be to include more fact sheets about other objects and enhancing existing entries. This will provide a more comprehensive overview of our knowledge about the Solar System. Moreover, a modular software design for the Console exhibit would enable its use for exploring other astronomical topics as well. Finally, improving the exhibit's accessibility for blind and visually impaired users is essential to ensure the usability of the Console. For example, by research-

Fig. 3. The Solar System Console. Left image: the exhibit of the Console. Right image: the main menu of the interface.

ing suitable colors and fonts and incorporating a screen reader, we can make the experience more accessible and inclusive for everyone.

5. Conclusions

The exhibits of the INAF telescopes virtual tour and the Solar System Console have had a great impact on the public and enjoyed especially by the younger audience. These new and emerging technologies applied to the public engagement offer an effective and powerful way to promote scientific culture. These exhibits provide a unique learning experience, engaging students through hands-on interaction and offering the flexibility to work independently or in groups guided by teachers.

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